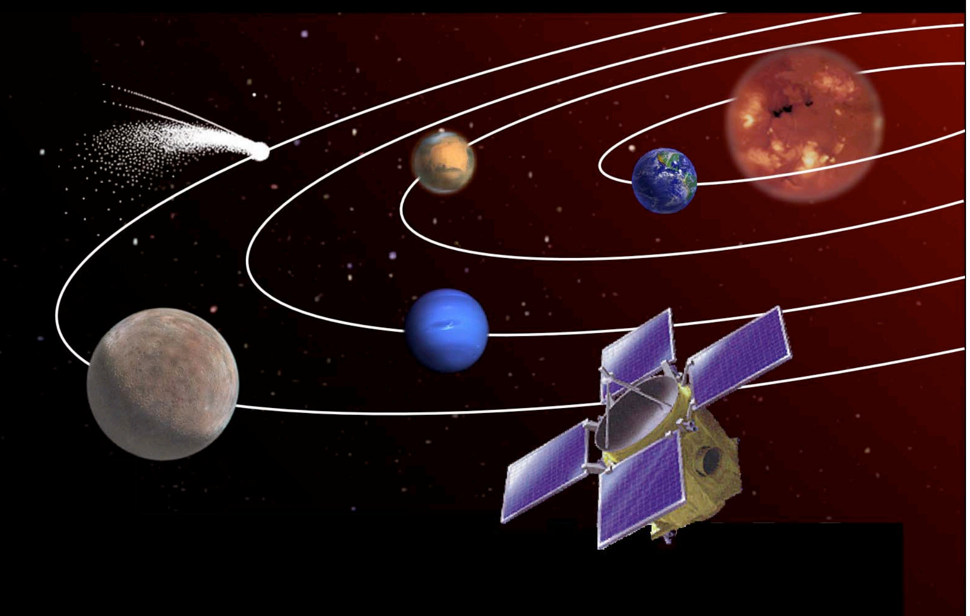
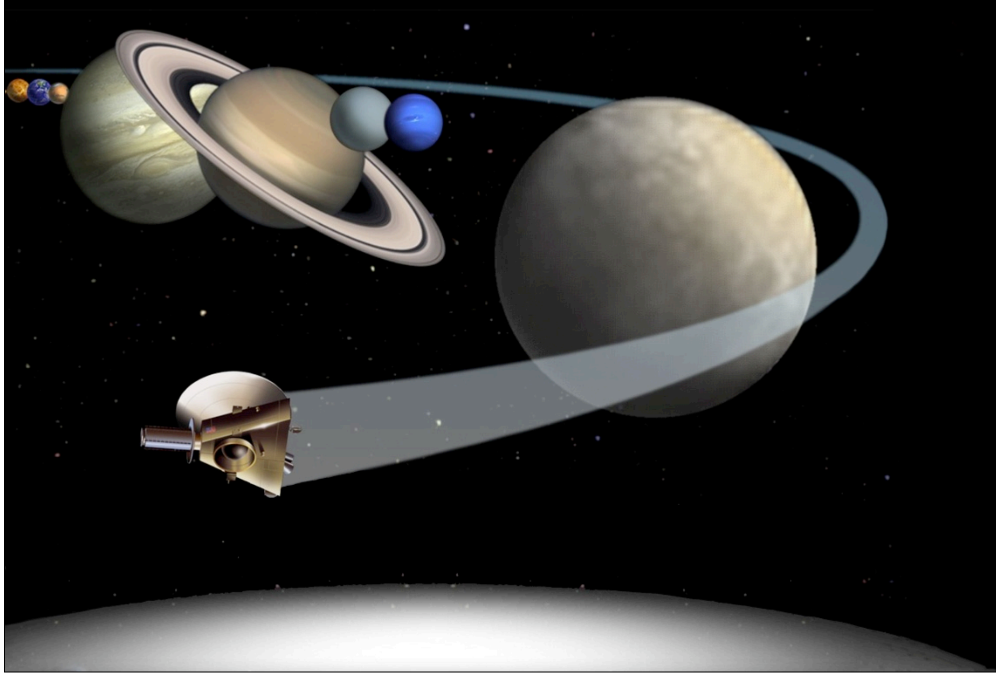
National Aeronautics and Space Administration

Briefing to Technology Panel





Discovery and New Frontiers (DNF) & Lunar Quest (LQ) Program Office

May 2010

Agenda

- DNF&LQ Program Overview
- DNF&LQ Programs Policy on New Technologies
- Life Cycle Cost Study
- Heritage and Technology Assumptions
- Technologies maturation and technology envelope expansion
- Summary

Discovery, New Frontiers, & Lunar Quest

Program Offices

Discovery Mission
LCC $425M
Target 24 month launch

New Frontiers Missions
LCC $650M
Target 54 month launch

Science Mission Directorate

Planetary Science Division

Discover/New Frontiers Missions are AO Competed, Cost Capped & are assigned to the PO at Phase B

Lunar Quest Missions are Directed & pre-formulation may be led by the PO

Aspera
Dawn
EPOXI
GRAIL
MESSENGER
Stardust-NExT
M^3
Strofio
Discovery AO 12 New Mission

Juno
New Horizons
NF AO 3 New Mission

LADEE
LRO Science
Robotic Lunar Lander Development Team (RLLDT)

Discovery, New Frontiers, & Lunar Quest Programs

Policy on New Technologies

DNF Programs

- Because of the cost cap nature of DNF Projects, heritage hardware and software is usually required
- The inclusion of new technologies to enhance performance or reduce cost is encouraged if risk mitigation measures are included

LQP Program

- LQP Missions encourages the use of high TLR technologies for flight missions
- However the program may invest in mission enabling technologies (ex. during mission pre-formulation) to achieve performance enhancements or reduce cost if risk mitigation measures are included.
  - Because LQP manages missions during pre-formulation, which may be lengthy, opportunities to provide for technology maturation exist

Discovery, New Frontiers, & Lunar Quest
Life Cycle Cost Study

Discovery, New Frontiers, and Lunar Quest

- Study Purpose:
  - DNF Projects can pass the confirmation gate reviews with unrealistic cost estimates, subsequent cost growth can cause projects to overrun reserves, exceed mission cost cap, and be subject to cancellation
- Study Objectives/Goals:
  - Assess mission development process irrespective of organizational responsibility
  - Provide assessment of LCC growth at **decision gates** throughout the mission development process
  - **Identify factors** that contribute to the occurrence of unplanned costs and significant mission cost cap overruns
  - Based on findings, provide **specific recommendations** and implementation plans to improve current processes and provide a greater level of insight to make better-informed decisions throughout the mission life-cycle
- Research Plan:
  - Select five candidate missions based on cost exceedance history
  - Collect historical data on each mission
  - Establish accepted historical timeline of mission cost increases (phases, major milestones, & decisions affecting)
  - Identify causes affecting cost increases over missions' life cycles

The final report on the Life Cycle Cost Growth Study for the Discovery and New Frontiers Program Office can be found in the New Frontiers Program Library; http://newfrontiers.larc.nasa.gov/NFPL.html

Discovery, New Frontiers, & Lunar Quest

Life Cycle Cost Study Findings List

INADEQUATE PLANNING FOR OPERATIONS / PHASE E	Project
OPTIMISTIC HARDWARE / SOFTWARE INHERITANCE and TECHNOLOGY READINESS ASSUMPTIONS	Project
INEXPERIENCED PROJECT TEAM FOR PLANETARY MISSIONS	Project
INSUFFICIENT MANAGEMENT OF AND INSIGHT INTO CONTRACTOR TASKS/PERFORMANCE	Project
LACK OF OR INADEQUATE INTEGRATED PROJECT SCHEDULES	Project
UNIQUE/SPECIAL TASKS/WORK OUTSIDE OF AREAS OF DEMONSTRATED EXPERTISE	Project
ADDITION OF NEW NASA REQUIREMENTS AFTER SELECTION	Project
INSTABILITY IN NASA PROGRAM BUDGETS	Project
NO LESSONS LEARNED FEEDBACK/FEED-FOWARD PROCESS	Program
INADEQUATE RISK MANAGEMENT PROCESS AT TRANSITION TO IMPLEMENTATION	Program
INADEQUATE CONSIDERATION OF INDEPENDENT REVIEW TEAM FINDINGS AND RECOMMENDATIONS	Program
INABILITY TO PROVIDE CREDIBLE COST ESTIMATES EARLY IN DEVELOPMENT	Program

Cross-cutting Findings & Recommendations
Heritage and Technology Assumptions

Optimistic hardware/software inheritance and technology readiness assumptions cause significant cost and schedule growth in phase C/D.

•Missions frequently propose the use of both, heritage and advanced technology systems in their designs to reduce the overall mission cost

•Projects optimistically believe to fully understand the characteristics of the proposed deployment Experience shows that institutional inheritance and technology readiness processes allow these system designs to complete design milestones with less scrutiny than new designs and allow cost/schedule escapes to occur which impact phase C/D

- Inadequate understanding of the heritage system’s performance within the proposed project design
- Project personnel with insufficient experience with the heritage system
- Poor scoping of impacts to implement a new technology for space flight

Unique features of a mission can be difficult to scope in terms of the effort and schedule required, the associated costs and the risks involved.

- Use of unproven technologies and other unique features such as nuclear powered systems and upper stages are examples of features which are not generally utilized in the Discovery program and require extra-ordinary efforts and time which are difficult to estimate in advance. The result can be unexpected demands on available resources and substantial increases in costs.

Use of new generation FPGA in heritage architecture C&DH System

- Early simplified brass board test yielded good results.
- More flight like testing conditions produced poor results that required many redesign cycles and created cost/ schedule issues

Pushing boundaries of heritage architecture to achieve Science Instrument Performance

- To meet Mission’s Science Instrument precision requirement and to ensure a statistically significant result, technical challenges in the areas of noise and systematic error reduction, stability, and false-positive rejection were experienced.
- Heritage Enhancement
- Enhancing and Expanding Heritage Architectures

Example
Heritage assumption

Utilization of "Heritage" Electric Propulsion systems for deep space missions

- Much of the electric propulsion system was assumed to be build-to-print or a slight deviation from a previous development
- In reality:
  - The drawings were inadequate to produce much of the propulsion system
  - Many components required a new development
- Problems were encountered adapting propulsion system design to mission
- Manufacturing issues was experienced further delaying delivering to I&T

Example
Technology Development During Mission Formulation

Use of Derivative ASRG (D ASRG) for Lunar Quest Mission

- International Lunar Network early pre-formulation assumed traded D ASRG as power system for light weight lunar lander.
- Early results looked promising (minimum fuel, adequate power).
- As mission design progresses:
  - Mission power requirements exceeded D ASRG capability
  - Concern surfaced that NASA demand for D ASRG might not support cost to facilitate production capability.

Summary

- Assumptions on Technology Readiness for a missions needs to be well documented and understood

- Definition of what Technology Readiness means
  - –TRL Levels related to Integrated Readiness Level of mission
  - – Expanding envelop of proven technology
  - –Technology guidelines and policies should provide better definition risk of adapting TRL 6 and TRL 7 technology to mission

Backup

Terms

- Technology Development
- Technology Maturation
- Technology Refinement
- Technology expansion
- Heritage

Technology Readiness Levels
Definitions

TRL 1 Basic principles observed and reported: Transition from scientific research to applied research. Essential characteristics and behaviors of systems and architectures. Descriptive tools are mathematical formulations or algorithms.

TRL 2 Technology concept and/or application formulated: Applied research. Theory and scientific principles are focused on specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.

TRL 3 Analytical and experimental critical function and/or characteristic proof-of- concept: Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies. Demonstration of technical feasibility using breadboard or brassboard implementations that are exercised with representative data.

TRL 4 Component/subsystem validation in laboratory environment: Standalone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.

TRL 5 System/subsystem/component validation in relevant environment: Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space): Prototyping implementations on full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.

TRL 7 System prototyping demonstration in an operational environment (ground or space): System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.

TRL 8 Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or space): End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation (V&V) completed.

TRL 9 Actual system "mission proven" through successful mission operations (ground or space): Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operational experience. Sustaining engineering support in place.